Received: 25 March 2024 | Accepted: 11 June 2024

DOI: 10.1111/aphw.12571

ORIGINAL ARTICLE

APPLIED PSYCHOLOGY: Health and Well-Being IAAP

The acute effects of nonsleep deep rest on perceptual responses, physical, and cognitive performance in physically active participants

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Abstract

This study aimed to examine the effect of nonsleep deep rest (NSDR) on physical and cognitive performance, as well as sleepiness, acute readiness, recovery, stress, and mood state in physically active participants. A total of 65 physically active participants (42 male, 23 female) were randomly assigned into two groups: an experimental group (NSDR, $n = 34$), in which participants completed a 10-min NSDR intervention, and a control group (CON, $n = 31$), whereby participants sat passively for 10 min. Testing measures were assessed immediately pre and 10 min post each condition and comprised completing a hand grip strength dynamometer test and a countermovement jump test on force plates, cognitive function measures via a psychomotor vigilance task (PVT-B), and a Simon task test, along with four questionnaires to assess sleep, recovery, and mood state. A significant Group × Time interaction favored the NSDR condition for handgrip strength, median reaction time during the PVT-B, and accuracy percentage during the Simon task. Questionnaire responses demonstrated NSDR to be associated with significant benefits to physical readiness, emotional

Funding information: No funding received.

balance, overall recovery, negative emotional state, overall stress, and tension in comparison to CON ($p < .05$). The NSDR intervention could be a valuable strategy for acutely enhancing overall well-being and readiness.

KEYWORDS

human performance, NSDR, recovery, relaxation, restoration

INTRODUCTION

Athletes typically experience suboptimal sleep durations and quality that fall below recommended levels (Walsh et al., 2021). This has been attributed to various factors, such as training and competition schedules (e.g. late night competition and early morning training) (Lastella et al., 2020), high training loads (Driller et al., 2023), frequent travel requirements (Janse van Rensburg et al., 2021), and elevated stress levels (Halson et al., 2022). While certain strategies, such as napping (Boukhris et al., 2023; Mesas et al., 2023), breathing with biofeedback (Li et al., 2022), and meditation (Jones et al., 2020; Li et al., 2018), have been identified as potential techniques to supplement nocturnal sleep and enhance both cognitive and physical performance, a relatively novel technique, termed nonsleep deep rest (NSDR), has been proposed as an alternative for enhancing recovery and performance. NSDR involves passively listening to a guided script inducing deep relaxation while maintaining consciousness and includes deep breathing, focus, and visualization exercises. NSDR may help athletes to reach a state of calm and therefore improve mood states, which has been proposed as an important factor for optimal performance (Brandt et al., 2021). However, there is currently limited research on the effects of NSDR in athletes.

While NSDR research is in its infancy, other relaxation techniques, including breathing techniques (Pelka et al., 2017), progressive muscular relaxation (PMR) (Hashim et al., 2011; McCloughan et al., 2016), breathing with biofeedback (Li et al., 2022), and yoga (Bucea-Manea-Țoniş et al., 2023), have been shown to positively influence performance and/or recovery in athletes. Indeed, strategies with a predominant cognitive focus have been linked to reductions in worry, self-assessed anxiety or pain, and an improvement in concentration (Pelka et al., 2016). On the other hand, techniques emphasizing skeletal muscle components tend to induce notable physiological effects, such as a decrease in heart rate and blood pressure (Pelka et al., 2016). In a systematic review that included six studies (Kim & Kim, 2021), enhanced athletic performance was attributed to positive physiological, technical and mental effects of meditation (i.e. imagery, meditation, and self-talk). Furthermore, it has been reported that a single 25-min session of either Yoga or mindfulness meditation resulted in improved mood states and cognitive performance at both 5- and 10-min postsession in healthy adult females participants (Luu & Hall, 2017). Similarly, it has been shown that a single 10-min meditation session resulted in immediate improvements in mood states in healthy young adult (Edwards & Loprinzi, 2018).

Unlike other relaxation techniques such as breathing techniques, PMR, and biofeedback, NSDR offers distinct characteristics. While breathing techniques often involve specific patterns or rhythms of breathing (Pelka et al., 2017), NSDR utilizes deep breathing as one component but extends further with visualization and body awareness exercises. In contrast, biofeedback relies on real-time physiological data for breathing adjustment (Li et al., 2022), whereas NSDR relies solely on a guided script (via speakers or headphones) for relaxation without external feedback or specialized equipment (e.g. biofeedback devices). Another similar technique, PMR, involves systematic muscle tension and relaxation, whereas NSDR facilitates relaxation through guided prompts and visualization. Therefore, while NSDR shares some similarities with the other relaxation techniques, its unique combination of guided prompts and focus on maintaining consciousness could distinguish it as a novel approach for relaxation and performance optimisation.

NSDR could potentially serve as a replacement for daytime napping and/or meditation, especially for individuals who do not habitually nap and cannot fall asleep during the day, as well as for individuals who find meditation difficult to practice (Lomas et al., 2015). Individuals may experience issues with mediation including, difficulty learning and practicing meditation, experiencing distressing thoughts and emotions, exacerbation of mental health issues such as anxiety and depression, and in some cases, the association of meditation with psychotic episodes (Lomas et al., 2015). Unlike meditation, NSDR does not necessitate specific training or expertise, significant effort, or a high degree of focus, making it a practically feasible option for implementation across several settings.

Furthermore, NSDR may present some advantages when compared with napping. NSDR may provide a more efficient and accessible alternative, as naps can vary in duration, with longer naps having the potential to interfere with night-time sleep (Lastella et al., 2021). In contrast, NSDR may offer a more controlled and predictable rest period lasting anywhere from 10 to 30 min. Unlike napping, which frequently requires a postnap recovery period of at least an hour to mitigate sleep inertia (Mesas et al., 2023), NSDR potentially eliminates this transition between sleep and wake. Additionally, napping typically requires a suitable environment, which may not always be readily available.

To our knowledge, there are no studies evaluating NSDR on cognitive and physical performance outcomes, as well as perceptual mood and wellbeing measures. Therefore, the purpose of the current study was to investigate the impact of a short (10 min) NSDR protocol on cognitive and physical performance, as well as sleepiness, acute readiness, recovery, stress, and mood states in physically active participants.

METHODS

Participants

A total of 65 physically active participants (42 M, 23 F, age: 21 ± 1 y, height: 174.8 ± 9.9 cm, body mass: 75.2 ± 13.6 kg) volunteered for the present study. Participants were recreational athletes who exercised for an average of 9 ± 4 h per week across a wide range of sports. Inclusion criteria required participants to partake in physical exercise for a minimum of 3 h per week. All participants were free from medical conditions and not taking medications that could interfere with their sleep or cognitive function. After receiving a thorough description of the protocol, each volunteer provided written informed consent. The present study was conducted according to the Declaration of Helsinki, and the protocol was approved by the Human Research Ethics Committee.

Experimental design

In the week prior to testing, participants were sent an electronic link to the NSDR protocol and completed a familiarization session. On the day of the testing session, participants were assigned to a control (CON, $n = 31$, M = 21, F = 10) or a NSDR ($n = 34$, M = 2 1, F = 13) group in a randomized, controlled, parallel-group design. The researchers conducting the testing were blinded to the group assignments of the participants. Participants were asked about their sleep duration for the night preceding the testing session using the following question: "*How many hours of sleep did you get last night?*". Participants were also asked if they were habitual nappers (yes or no, for napping >1 time per week) and if yes were asked to provide details on the frequency of naps per week. Testing occurred across late morning/early afternoon for all participants, with equal numbers of participants allocated to each group at each time point. Participants in the experimental group practiced a 10-min NSDR intervention lying down on a mat in a quiet room with the lights turned off. The NSDR intervention consisted of a 10-min session of deep guided relaxation exercises (found here: https://youtu.be/AKGrmY8OSHM). Meanwhile, participants in the CON group sat passively for 10 min in a separate room under the supervision of one of the research team members. This supervision ensured compliance and prevented participants from practicing any relaxation techniques, napping, or using electronic devices.

All testing measures were performed immediately pre-intervention and 10-min post-intervention for both NSDR and CON trials. Each testing condition composed of measuring physical performance (using handgrip strength and a countermovement jump [CMJ] on force platforms), cognitive performance (brief psychomotor vigilance task [PVT-B] and Simon task), and subjective measures using four questionnaires. Daytime sleepiness was measured using the Stanford Sleepiness Scale (SSS), acute readiness using the Acute Readiness Monitoring Scale (ARMS), stress and recovery using the short recovery and stress scale (SRSS), mood states using the Brunel Mood Scale (BRUMS). In addition, upon completion of the testing session, participants in the NSDR group were asked to rate their enjoyment of the NSDR condition on a scale ranging from 0 to 10 (0 = very dissatisfied and 10 = very satisfied) and were asked if they would use the technique again (yes or no). The study schematic and timeline are outlined in Figure 1.

Physical performance

All physical tests (both pre and post) were preceded with a standardised warm-up, involving a series of exercises: 10 bodyweight squats, followed by 5 CMJs progressing from 50 per cent to 90 per cent effort, ending with two maximal jumps. Participants rested for 2 min (passive rest) between the warm-up and the beginning of testing.

Handgrip strength

Grip strength for the dominant hand was recorded using a hand dynamometer (Jamar Plus Digital, Paterson Medical, Green Bay, WI, USA). Positioning was standardised, with the handheld dynamometer adjusted to each individual's hand size. The participant gripped the dynamometer while in a standing position, with shoulders adducted and neutrally rotated, elbow flexed to 90°, forearm in neutral position with wrist between 0° and 30° of extension and

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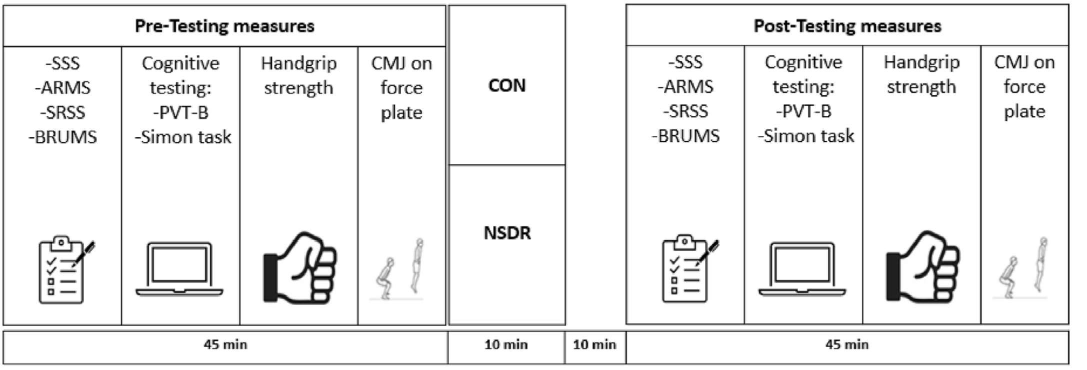

FIGURE 1 Schematic representation of the experimental design. ARMS, acute readiness monitoring scale; BRUMS, Brunel mood scale; CMJ, countermovement jump; CON, control condition; NSDR, nonsleep deep rest; SRSS, short recovery and stress scale; SSS: Stanford sleepiness scale.

0°–15° of ulna deviation and feet flat on the floor. Participants had three attempts at a maximal squeeze, with the highest value at each time point (pre and post) used for analysis (measured in kg). High levels of reliability and validity for the grip strength test have been reported previously (Hamilton et al., 1994), establishing it as the "gold standard" for measuring grip strength.

CMJ

Three CMJs were performed on a dual force platform system (ForceDecks, VALD Performance, Australia). Prior to each participant, the force platforms were zeroed. Participants were then asked to step on the center of the force platforms and stand "as still as possible" to record an accurate measurement of body weight. The recording was initiated, and participants were asked to stand as still as possible with hands akimbo for the count of "3-2-1." On "JUMP", they were instructed to jump as high as possible using a self-selected countermovement depth. This was repeated for three trials, with 10 s of passive rest in between. The trial with the highest jump height (cm) was selected for further analysis. Jump height (cm, calculated using the impulse-momentum method), concentric mean force ([N] defined as the mean force between the start of positive velocity to take-off), and reactive strength index-modified (RSI-mod) (m/s) were obtained from the force platform software. The test–retest reliability of these metrics performed on the same force plate system has been deemed acceptable in recreational adults (Merrigan et al., 2022).

Cognitive performance

PVT-B

The PVT-B is a validated assessment tool for measuring sustained attention and vigilance (Basner et al., 2011). It requires participants to observe a laptop screen using a free, open-source software system (The Psychology Experiment Building Language—PEBL, Version 2.1) and pressing the spacebar button as quickly as possible as a stimulus light appears. This action stops the timer and presents the reaction time in milliseconds for a duration of 1 s. The intervals between stimuli were randomly varied, ranging from 2 to 10 s (Basner et al., 2011), which also included a 1-s reaction time feedback interval. The task lasted 4 min, with the initial minute designated for practice, and data collection occurred during the subsequent 3 min. The outcomes obtained from the PVT-B were the mean and median reaction time (in milliseconds). Participants were instructed to respond as quickly as possible, in order to keep reaction time as low as possible, but not to press the spacebar button too soon (which returned a false start warning on the display).

The Simon task

The Simon task (Simon, 1990) is a behavioral measure of interference/conflict resolution targeting cognitive control, namely, response selection and inhibition/suppression. Participants sat facing a laptop screen (using the same PEBL software as described above) and were tasked to quickly and accurately press the appropriate response key (using the right or left thumb) based on the color of a circle (red or blue) appearing either to the left or right of the fixation point. Participants were instructed to focus on the relevant stimulus feature (color) and ignore the irrelevant feature (spatial location). For a red circle, participants were to press the left shift button, and for a blue circle, the right shift button was to be pressed. The task involved a set of 70 non-blocked trials, with an even distribution into two trial types presented randomly: congruent trials (response side matching the stimulus side) and incongruent trials (response side opposite to the stimulus side). Upon pressing a response key or after 1.5 s had passed without a response, the stimulus was removed from the screen, initiating the commencement of the next trial. Performance was measured in terms of both mean reaction time (milliseconds, ms) and accuracy rate (%).

Subjective measures

The SSS

Participants select one of seven statements to describe their current level of sleepiness, each corresponding to a specific scale value: 1—feeling active and vital, alert, wide awake; 2—functioning at a high level, but not at peak, able to concentrate; 3—relaxed, awake, not at full alertness, responsive; 4—a little foggy, not at peak, let down; 5—fogginess, beginning to lose interest in remaining awake, slowed down; 6—sleepiness, prefer to be lying down, fighting sleep, woozy; 7—almost in reverie, sleep onset soon, lost struggle to remain awake. The sleepiness perception score is determined by the selected statement. The use of the SSS to assess sleepiness perception has been shown to be valid and reliable with an agreement of 88 per cent (Hoddes et al., 1973).

The ARMS

The ARMS is a 32-item scale that is designed to assess acute, multidimensional readiness (Summers et al., 2021). The questionnaire has nine factors of readiness: (1) Overall Readiness,

(2) Physical Readiness, (3) Physical Fatigue, (4) Cognitive Readiness, (5) Cognitive Fatigue, (6) Threat-Challenge Readiness, (7) Group-Team Readiness, (8) Skills-Training Readiness, and (9) Equipment Readiness. Data from readiness factors 1–6 were used for analysis, while the remaining factors (7–9) were excluded, as these items were not relevant to the study aims and methods. The items were scored on a 7-point Likert scale ("0" = does not apply at all to "6"= fully applies). A reverse score was applied to items related to physical fatigue and mental fatigue.

The SRSS

The SRSS assesses the current recovery-stress state of an athlete on an emotional, mental, physical, and overall stress and recovery level (Kölling et al., 2020). The SRSS is a standardised self-assessment procedure and includes the items physical performance capability, mental performance capability, emotional balance, and overall recovery in the short recovery scale and muscular stress, lack of activation, negative emotional state, and overall stress in the short stress scale. The SRSS was derived from the eight scales of the acute recovery and stress scale (ARSS), which were then grouped into the Short Recovery Scale and the Short Stress Scale and consist of four items each (Kölling et al., 2020). The level of agreement is determined by a 7-point Likert scale ("0" = does not apply at all to "6" = fully applies).

The BRUMS

The BRUMS (Terry et al., 2003) is a scale of 24 mood descriptors using a standard response timeframe of "How do you feel right now?". Participants rated their mood responses on a 5-point Likert scale of 0 = not at all, 1 = a little, 2 = moderately, 3 = quite a bit, and 4 = extremely. The BRUMS has six subscales (anger, confusion, depression, fatigue, tension, and vigor), with four items under each subscale. The total subscale scores range from 0 to 16.

Statistical analysis

The data are presented as means ± standard deviation (*SD*), and statistical analysis was conducted using Statistica software (StatSoft, France, version 10).

The normality of the distributions was confirmed through the Shapiro–Wilk test. A two-way mixed analysis of variance (ANOVA) (Condition × Time) was employed to analyze all data (except sleep duration and characteristics of participants). In cases where ANOVA results revealed a significant main effect among conditions, times, or an interaction, post hoc comparisons were conducted using the Bonferroni test to examine pairwise comparisons. For sleep duration, height, weight, body mass index (BMI), and physical activity, an independent *t*-test was performed to examine significant differences between groups (CON vs. NSDR). However, when normality was not confirmed, a Mann–Whitney *U* test was used for age.

The effect size was calculated using partial eta-squared ($\eta_p{}^2$). Effect sizes of 0.01, 0.06, and 0.14 were indicative of "*small*," "*moderate*," and "*large*" effect sizes, respectively (Lakens, 2013).

The level of statistical significance was set at $p < .05$ for all statistical tests. While exact p-values are provided, any results reported as "0.000" in the statistical output have been represented in the present publication as "<.001."

RESULTS

Participants' characteristics of the subgroups samples are presented in Table 1. Statistical analysis showed that participants' characteristics were similar between NSDR and CON groups ($p > .05$).

Sleep duration during the night preceding the testing session, nap frequencies, and NSDR enjoyment are presented in Table S1. Statistical analysis showed that preceding night sleep duration was similar between NSDR and CON groups ($p > .05$).

ANOVA results for all data are presented in supporting information Table S2.

Physical performance

Handgrip strength

A significant Condition × Time interaction for handgrip strength ($F_{(1,30)} = 7.51$, $p = .010$, ${\eta_p}^2 = 0.20$) was observed. The post hoc Bonferroni test revealed that handgrip strength values increased by 4 per cent after NSDR ($p = .034$) compared with a nonsignificant decrease of 1.1 per cent in CON. In addition, handgrip strength values were significantly higher both before ($p = .010$) and after ($p < .001$) the NSDR condition compared with the CON condition (Figure 2).

CMJ

There were no significant interactions or main effects for jump height, concentric mean force, or RSI-mod from the CMJ.

TABLE 1 Characteristics of the participants in the control group and the nonsleep deep rest (NSDR) group.

	Control group	NSDR group
Number of female participants	10	13
Number of male participants	21	21
Age (years)	21.5 ± 2.0	21.0 ± 0.6
Height (cm)	174 ± 10	176 ± 10
Weight (kg)	75 ± 14	76 ± 14
BMI	24.5 ± 3.1	24.2 ± 3.0
Physical activity (hours/week)	9.4 ± 3.5	8.9 ± 3.7

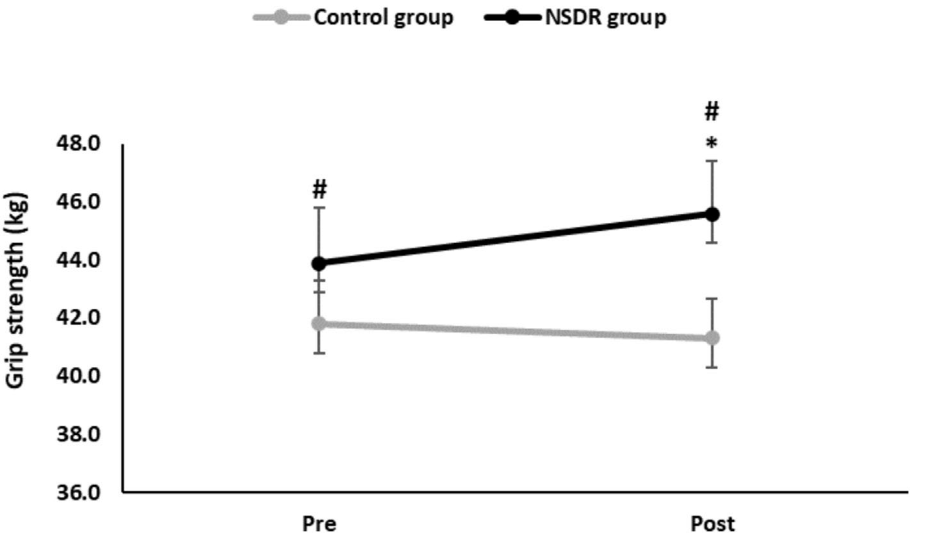

FIGURE 2 Hand grip strength recorded pre and post each condition (control and NSDR: nonsleep deep rest) including group means (with *SD*). *: significant pre to post difference, #: significant difference compared with control group.

Cognitive performance

PVT-B

Mean reaction time during the PVT-B (Table 2 and Figure 3) resulted in a significant Time effect ($F_{(1,30)} = 11.83$, $p = .002$, $\eta_p{}^2 = 0.28$) with the post hoc Bonferroni test revealing that mean reaction time values decreased by 6.1 per cent after the NSDR condition ($p < .001$) compared with a nonsignificant decrease of 3.3 per cent in CON. In addition, mean reaction time values were significantly lower after the NSDR condition compared with after the CON condition ($p = .015$).

There was a significant Condition × Time interaction for median reaction time ($F_{(1,30)} = 6.13$, $p = .019$, $\eta_p{}^2 = 0.17$) (Table 2). The post hoc Bonferroni test revealed that median reaction time values decreased by 3.9 per cent after the NSDR condition ($p < .001$) compared with a nonsignificant decrease of 0.7 per cent in CON.

Regarding the fastest reaction time from the PVT (Table 2), there was a significant main effect for Time ($F_{(1,30)} = 8.33$, $p = .007$, $\eta_p{}^2 = 0.22$). The post hoc Bonferroni test revealed that mean reaction time decreased by 4.0 per cent after the NSDR condition ($p = .018$) compared with a nonsignificant decrease of 2.0 per cent in CON.

Simon task

There was a significant Time effect for reaction time for correct trials in the Simon Task ($F_{(1,30)} = 22.84$, $p < .001$, $\eta_p{}^2 = 0.43$). The post hoc Bonferroni test revealed that reaction time for correct trials values decreased by 5.6 per cent after the NSDR condition ($p = 0.001$) in comparison to a nonsignificant decrease of 2.2 per cent in CON.

TABLE 2 Cognitive performance recorded during the brief psychomotor vigilance task (PVT-B) and Simon task pre and post each condition (CON and NSDR).

	Control group		Δ Pre to post	NSDR group		Δ Pre to post	Condition × time effect size
	Pre	**Post**		**Pre**	**Post**		
Mean reaction time during PVT-B (ms)	331.7 ± 41.4	318.0 ± 26.5	−13.7 ± 37.7	326.9 ± 37.3	305.0 ± 24.2[a]	−21.9 ± 29.6[b]	0.07
Median reaction time during PVT-B (ms)	302.2 ± 31.8	298.5 ± 23.5	−3.7 ± 28.9	307.9 ± 36.3	293.7 ± 22.4	−14.2 ± 29.6[b]	**0.17**
Fastest reaction time during PVT (ms)	247.8 ± 22.2	241.8 ± 16.1	−6.0 ± 17.7	249.8 ± 29.8	238.3 ± 27.6	−11.5 ± 25.0[b]	0.04
Mean reaction time for correct trials during Simon task (ms)	424.9 ± 44.0	413.4 ± 44.0	−11.4 ± 29.4	425.9 ± 54.2	399.6 ± 36.6	−26.3 ± 36.9[b]	0.09
Accuracy percentage during Simon task (%)	93.0 ± 4.4	92.6 ± 4.8	−0.4 ± 3.5	93.7 ± 4.7	95.5 ± 3.9[a]	1.9 ± 2.8[b]	**0.19**

Note: A bold value for the effect size means a significant interaction with $p < .05$.

Abbreviations: CON, control group; NSDR: nonsleep deep rest; PVT-B, brief psychomotor vigilance task.

[a]Significant difference between NSDR and CON groups.

[b]Significant pre to post difference.

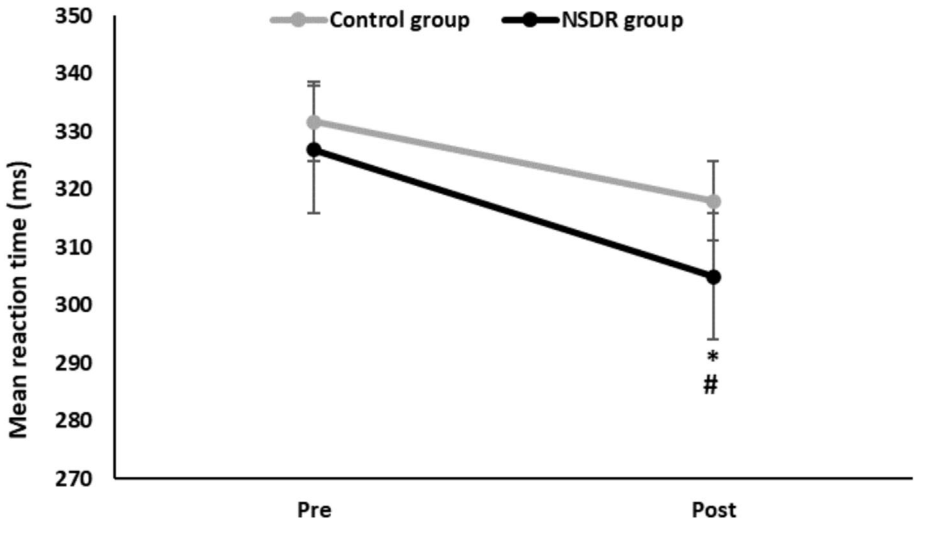

FIGURE 3 Mean reaction time recorded during the psychomotor vigilance task pre and post each condition (control and NSDR: nonsleep deep rest) including group means (with *SD*). *: significant pre to post difference, #: significant difference compared with control group.

A significant Condition × Time interaction (Table 2, Figure 4) was observed for accuracy during the Simon Task ($F_{(1,30)} = 7.11$, $p = .012$, $\eta_p{}^2 = 0.19$). The post hoc Bonferroni test revealed that accuracy percentage increased by 2.0 per cent after the NSDR condition ($p = .026$) in comparison with a nonsignificant increase of 0.5 per cent in CON. In addition, accuracy percentage was significantly higher after the NSDR condition compared with after the CON condition ($p < .001$).

Perceptual measures

Sleepiness

A significant Time effect was observed for sleepiness ($F_{(1,30)} = 8.06$, $p = .008$, $\eta_p{}^2 = 0.21$). However, the post hoc Bonferroni test did not identify any significant pairwise comparisons (Table 2).

ARMS

A significant Condition × Time interaction was observed for physical readiness ($F_{(1,30)} = 10.44$, $p = 0.003$, $\eta_p{}^2 = 0.26$) (Table 3). The post hoc Bonferroni revealed that physical readiness values increased by 6.5 per cent after the NSDR condition ($p = .026$), while there was a nonsignificant decrease of 4.3 per cent in CON.

Although there was a significant Condition effect for the overall readiness ($F_{(1,30)} = 5.50$, $p = .026$, $\eta_p{}^2 = 0.15$) (Table 3) and a significant Time effect for the physical fatigue

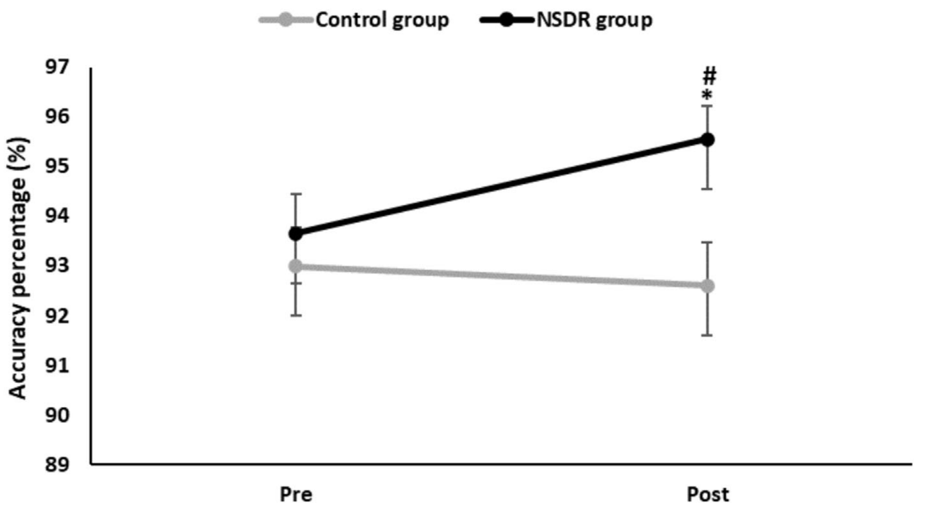

FIGURE 4 Accuracy percentage recorded during the Simon task pre and post each condition (control and NSDR: nonsleep deep rest) including group means (with *SD*). *: significant pre to post difference, #: significant difference compared with control group.

($F_{(1,30)} = 5.66$, $p = .024$, ${\eta_p}^2 = 0.16$) (Table 3), the post hoc Bonferroni test did not identify any significant pairwise comparisons.

SRSS

There was a significant Condition × Time interaction for emotional balance ($F_{(1,30)} = 4.44$, $p = .043$, ${\eta_p}^2 = 0.13$) and negative emotional state ($F_{(1,30)} = 13.03$, $p = 0.001$, ${\eta_p}^2 = 0.30$). The post hoc Bonferroni revealed a significant increase of 10.5 per cent in emotional balance values ($p = .021$) after the NSDR condition compared with a nonsignificant decrease of 9.9 per cent in CON and a significant decrease in negative emotional state values ($p = .002$) after the NSDR condition (Table 3).

There were a significant Condition × Time interaction ($F_{(1,30)} = 14.96$, $p < .001$, ${\eta_p}^2 = 0.33$; $F_{(1,30)} = 4.40$, $p = .044$, ${\eta_p}^2 = 0.13$, respectively) and a significant Time effect ($F_{(1,30)} = 20.54$, $p < .001$, ${\eta_p}^2 = 0.41$; $F_{(1,30)} = 9.87$, $p = .004$, ${\eta_p}^2 = 0.25$, respectively) for overall recovery and stress. The post hoc Bonferroni test revealed a significant 28.2 per cent increase in overall recovery values ($p < .001$) after the NSDR condition and a significant 17.3 per cent decrease in overall stress values ($p = .007$) after the NSDR condition (Table 3). In addition, overall recovery values were significantly higher after the NSDR condition compared with after the CON condition ($p < .001$).

A significant Time effect was observed for muscular stress ($F_{(1,30)} = 9.40$, $p = .005$, ${\eta_p}^2 = 0.24$) (Table 3). The post hoc Bonferroni test revealed that muscular stress values decreased by 36.6 per cent after the NSDR condition ($p = .021$) compared with a nonsignificant decrease of 21.0 per cent in CON. In addition, muscular stress values were significantly lower after the NSDR condition compared with after the CON condition ($p = .006$).

TABLE 3 Perceptual measures of sleepiness, acute readiness monitoring scale (ARMS), short recovery and stress scale (SRSS), and Brunel mood scale (BRUMS) recorded pre and post each condition (CON and NSDR).

		Control group			NSDR group			Condition × time
		Pre	Post	Δ Pre to post	Pre	Post	Δ Pre to post	effect size
Sleepiness (1–7)		3.1 ± 0.7	2.9 ± 0.9	−0.2 ± 0.8	3.3 ± 0.7	2.8 ± 1.1	−0.4 ± 1.0	0.01
ARMS (0–24)	Overall readiness	16.5 ± 2.8	16.8 ± 3.7	0.3 ± 2.8	14.1 ± 4.7	15.1 ± 4.3	1.0 ± 3.5	0.03
	Physical readiness	12.9 ± 2.6	12.4 ± 2.6	−0.5 ± 1.3	12.3 ± 2.8	13.2 ± 2.4	0.9 ± 2.1[a]	**0.26**
	Physical fatigue	12.8 ± 5.1	13.3 ± 4.2	0.5 ± 0.6	12.9 ± 4.8	14.6 ± 4.6	1.7 ± 3.2	0.06
	Cognitive readiness	11.5 ± 2.5	11.2 ± 3.1	−0.3 ± 2.8	11.1 ± 3.0	12.2 ± 3.4	1.1 ± 2.9	0.08
	Cognitive fatigue	10.5 ± 3.9	10.9 ± 3.3	0.4 ± 3.0	10.5 ± 3.6	11.9 ± 4.1	1.4 ± 3.2	0.08
	Threat-challenge readiness	15.8 ± 3.4	16.1 ± 4.0	0.3 ± 2.4	14.9 ± 4.1	16.1 ± 4.5	1.3 ± 3.1	0.04
SRSS (0–6)	Physical performance capability	3.8 ± 0.8	4.0 ± 1.0	0.1 ± 1.0	3.6 ± 1.1	3.9 ± 1.2	0.2 ± 1.1	0.002
	Mental performance capability	3.6 ± 1.0	3.6 ± 1.1	0.0 ± 0.9	3.5 ± 0.8	3.9 ± 1.2	0.5 ± 1.1	0.07
	Emotional balance	4.1 ± 1.1	4.2 ± 1.1	0.0 ± 1.1	3.9 ± 1.1	4.5 ± 1.1	0.6 ± 1.0[a]	**0.13**
	Overall recovery	3.0 ± 1.1	3.2 ± 0.9	0.2 ± 1.0	2.9 ± 1.2	4.1 ± 1.1[b]	1.2 ± 1.2[a]	**0.33**
	Muscular stress	3.3 ± 1.3	3.1 ± 1.2	−0.3 ± 1.1	3.1 ± 1.7	2.4 ± 1.3[b]	−0.7 ± 1.1[a]	0.06

(Continues)

TABLE 3 (Continued)

		Control group			NSDR group			Condition × time effect size
		Pre	Post	Δ Pre to post	Pre	Post	Δ Pre to post	
	Lack of activation	2.3 ± 1.2	2.3 ± 1.2	0.0 ± 0.9	2.5 ± 1.3	2.0 ± 1.2	−0.5 ± 1.5	0.04
	Negative emotional state	1.0 ± 0.8	1.2 ± 1.0	0.2 ± 0.8	1.4 ± 1.4	0.8 ± 0.8	−0.6 ± 1.0[a]	**0.30**
	Overall stress	2.4 ± 1.4	2.3 ± 1.3	−0.1 ± 1.0	2.6 ± 1.8	1.9 ± 1.5	−0.7 ± 1.2[a]	**0.13**
BRUMS (0–4)	Anger	1.0 ± 1.4	0.6 ± 1.1	−0.5 ± 1.1	1.4 ± 2.4	0.3 ± 1.0	−1.1 ± 2.0[a]	0.11
	Confusion	1.7 ± 2.4	1.1 ± 1.5	−0.6 ± 1.6	2.0 ± 2.1	0.9 ± 1.9	−1.1 ± 1.8[a]	0.04
	Depression	1.0 ± 1.5	0.7 ± 1.2	−0.3 ± 0.8	1.1 ± 2.1	0.5 ± 1.7	−0.6 ± 0.7[a]	0.11
	Fatigue	6.3 ± 3.4	5.0 ± 3.8	−1.3 ± 2.5	6.3 ± 4.0	4.0 ± 3.1	−2.4 ± 3.1[a]	0.07
	Tension	1.9 ± 2.0	1.5 ± 2.1	−0.4 ± 1.4	2.2 ± 2.9	0.6 ± 1.6	−1.6 ± 2.2[a]	**0.21**
	Vigor	9.0 ± 2.8	9.2 ± 3.0	0.2 ± 2.1	7.2 ± 3.1	8.1 ± 3.4	0.9 ± 3.9	0.02

Note: A bold value for the effect size means a significant interaction with $p < .05$.

Abbreviations: CON, control group; NSDR: nonsleep deep rest.

[a]Significant pre to post difference.

[b]Significant difference between NSDR and CON groups.

BRUMS

There were a significant Condition × Time interaction ($F_{(1,30)} = 7.75$, $p = .009$, ${\eta_p}^2 = 0.21$) and a significant Time effect ($F_{(1,30)} = 15.81$, $p < .001$, ${\eta_p}^2 = 0.35$) for tension from the BRUMS (Table 3). The post hoc Bonferroni test revealed that tension values decreased after the NSDR condition ($p < .001$).

A significant Time effect was observed for anger ($F_{(1,30)} = 14.01$, $p < .001$, ${\eta_p}^2 = 0.32$), confusion ($F_{(1,30)} = 19.86$, $p < .001$, ${\eta_p}^2 = 0.40$), depression ($F_{(1,30)} = 27.25$, $p < .001$, ${\eta_p}^2 = 0.48$), and fatigue ($F_{(1,30)} = 27.32$, $p < .001$, ${\eta_p}^2 = 0.48$). The post hoc Bonferroni revealed a significant decrease in anger ($p < .001$), confusion ($p = .008$), depression ($p < .001$), and fatigue ($p < .001$) after the NSDR condition (Table 3).

DISCUSSION

This study is the first to assess the effects of a 10-min NSDR protocol on physical and cognitive performance, along with perceptual assessments of acute readiness, recovery stress, and mood. The main findings showed that NSDR yielded favorable outcomes, including enhanced handgrip strength and improved cognitive performance, as evidenced by various measures during the PVT and Simon Tasks. NSDR was also associated with enhanced perceptions of physical readiness, emotional balance, and overall recovery, along with a reduction in muscular stress, and mitigation of negative emotional states, overall stress, anger, confusion, depression, fatigue, and tension. However, sleepiness and jump performance were not affected by NSDR.

While NSDR shares some elements with other relaxation techniques (e.g. meditation, PMR, and deep breathing exercises), its uniqueness lies in its combined approach and specific goals. Unlike meditation, that aims for a state of detached awareness or mindfulness (Kim & Kim, 2021), NSDR focuses on achieving deep relaxation while maintaining consciousness. Additionally, the guided nature of NSDR, with structured scripts incorporating visualization and body awareness, offers a more directed experience compared with the open-ended nature of many meditation practices. This combination of conscious relaxation, guided structure, and targeted outcomes establishes NSDR as a novel and easily accessible strategy without the need for specialist expertise or equipment.

The observed improvements in handgrip strength suggest that NSDR could be an effective recovery strategy for optimizing strength performance, which is of particular interest to athletes and individuals engaged in physical training programs. In fact, grip strength has been used as an indicator of overall strength (Wind et al., 2010) in active participants, playing a crucial role in optimizing performance and mitigating the risk of injuries (Cronin et al., 2017). The present findings, showing a 4 per cent increase in handgrip strength after a single 10-min NSDR session, align with research on other recovery strategies with similar relaxation components. For example, significant improvements in handgrip strength were reported, with increases of 8 per cent after 3 months of 20-min sessions of PMR (Chaudhuri et al., 2014), 112 per cent following 6 months of 45-min sessions of yoga (Nambinarayanan et al., 1992), and 17 per cent after 12 weeks of 30-min sessions of yoga (Bhavanani, 2003). The enhancement in strength following NSDR may be related to heightened parasympathetic activity. NSDR has the potential to induce a profound state of relaxation, potentially promoting increased parasympathetic tone. This heightened parasympathetic activity could foster an optimal recovery, influencing factors such as reduced muscle tension and improved blood flow (Thomas & Segal, 2004), ultimately contributing to enhanced strength.

Despite improvements in handgrip strength, jump performance did not exhibit a positive response to the NSDR protocol in the current study. A recent meta-analysis reported that jump height performance remained unchanged after a nap opportunity (Boukhris et al., 2023). The short duration of nap opportunities and the insufficient time allotted to prevent sleep inertia were proposed as factors accounting for the lack of improvement following napping (Boukhris et al., 2023). While we can only speculate, the short 10-min duration of NSDR session may not have provided sufficient time to induce noticeable changes in jump performance. Another possible explanation for the absence of significant improvement during the CMJ is the increased technicality and coordination required for the movement compared with handgrip strength. Consequently, future research should explore extending the duration of NSDR sessions and to observe any subsequent impact on jump performance.

The current study revealed significant improvements in cognitive performance following the NSDR condition, as evidenced by measures in both the PVT-B and Simon task. This suggests that NSDR may have an influence on various cognitive domains, particularly attentional, executive functions (involving inhibition, monitoring, and task-switching), and motor processes (Cespón et al., 2020). These cognitive improvements are particularly relevant for sports that require a high degree of attention and vigilance to effectively manage and resolve complex situational challenges during gameplay (Trecroci et al., 2021; Vestberg et al., 2012). Previous studies exploring the impact of Yoga Nidra report similar improvements in cognitive function (Arti et al., 2022; Datta et al., 2023). As such, NSDR may elicit a similar state to Yoga Nidra and contribute to improved cognitive function that results in heightened focus and mental clarity.

As the interaction between performance and subjective markers/perception is highly important (McCall et al., 2023), in the present study, the improvement in muscular strength and cognitive performance may be attributed to the rest provided by the NSDR protocol. Indeed, perceptual responses for acute readiness (i.e. physical readiness), recovery state (i.e. emotional balance and overall recovery), stress state (i.e. reduction of muscular stress, mitigation of negative emotional states, and overall stress levels), and mood states (i.e. reduced anger, confusion, depression, fatigue, and tension) were positively affected by the NSDR protocol, which could explain the improvements seen in some of the physical and cognitive measures. In accordance with the present findings, other recovery strategies similar to NSDR, such as 25 min of systematic breathing (Pelka et al., 2017), 11 min of Yoga Nidra meditation (Moszeik et al., 2022), and napping (Boukhris et al., 2023; Lastella et al., 2021), were relatively beneficial to improve mood states and reduce stress. Indeed, when participants experience enhanced readiness, improved recovery, reduced stress, and exhibit a positive mood, these psychological factors may contribute to creating an optimal mental state, leading to improved cognitive and physical performance (Stoeber, 2011). The literature supports the role that emotional and psychological well-being plays in determining an individual's ability to perform optimally in various tasks and activities (Brandt et al., 2017; Stoeber, 2011). In the current study, the effectiveness of NSDR as a recovery strategy was supported by an enjoyment rating of 7.3 out of 10, with 71 per cent of participants expressing their intent to use NSDR again.

The beneficial effect of NSDR could be related to the fact that NSDR may decelerate brainwave frequencies, replicating the patterns similar to those observed during light sleep (LS) and/or slow-wave sleep (SWS), without facilitating sleep. Both LS and SWS play a crucial role in the recovery process, contributing significantly to both physical and mental restoration (Genzel et al., 2014; Shapiro et al., 1981; Walsh et al., 2021). Additionally, LS and SWS are essential for consolidating memories, enhancing cognitive function, and regulating mood, particularly through increased parasympathetic activation (Rasch & Born, 2013; Walker, 2009). Future studies should accurately measure electroencephalogram (EEG), electrocardiogram (ECG), and electrooculogram (EOG) signals during NSDR using polysomnography to further elucidate the potential mechanisms involved.

The positive effects of the NSDR protocol may also be influenced by the inclusion of controlled breathing, which is effective in reducing sympathetic tone to a greater extent than mindfulness meditation practice (Balban et al., 2023). Moreover, it has been reported that controlled breathing may influence cortical structures that regulate mood, emotion, and arousal (Balban et al., 2023). In fact, slowing down the breathing rhythm during NSDR could potentially signal higher-order brain structures linked to behavioral arousal, generating a heightened sense of calm (Balban et al., 2023).

The present study presents novel findings; however, it is not without limitations. The main limitation of the current study was the absence of objective measurements such as EEG, ECG, and EOG during the NSDR protocol, preventing an in-depth examination of whether participants entered a comparable state of light/deep sleep or not. A further limitation of the current study was the lack of control across some aspects of the study. For example, nutrition, sleep, physical activity, and training data before the experimental sessions were not controlled for, and there is potential for these variables to influence cognitive and physical performance. However, given the pre-post nature of our study design, we would suggest that this accounts for some of these limitations. We were also limited by the use of the pre and post measurement time-points only. Future work should consider the time course of any changes following NSDR use, different length protocols of NSDR, and the comparison of habitual versus nonhabitual NSDR participants. Indeed, participants in the current study would be considered as novice NSDR users, with limited experience of the technique. Furthermore, comparing NSDR to napping, or other short interventional protocols, would also provide valuable insight into the efficacy of this technique.

CONCLUSION

The NSDR protocol was associated with improvements in both physical and cognitive performance. This enhanced performance linked to NSDR may be attributed to improvements in physical readiness, recovery state, and mood states, as well as a reduction in stress levels. Therefore, NSDR could serve as an effective strategy to optimize cognitive and physical performance in both training and competition settings in athletes. Given the short duration required for NSDR, this technique may be practically feasible to implement prior to competition or between morning and afternoon training sessions.

AUTHOR CONTRIBUTIONS

Conceptualization: Omar Boukhris, Haresh Suppiah, and Matthew Driller. *Methodology*: Omar Boukhris, Haresh Suppiah, Shona Halson, Suzanna Russell, Anthea Clarke, and Matthew Driller. *Software*: Omar Boukhris. *Formal analysis*: Omar Boukhris. *Data collection*: Omar Boukhris, Anthea Clarke, Mary C. Geneau, Luke Stutter, and Matthew Driller. *Data curation*: Omar Boukhris, Haresh Suppiah, and Matthew Driller. *Writing—original draft preparation*: Omar Boukhris. *Writing—review and editing*: Omar Boukhris, Haresh Suppiah, Shona Halson, Suzanna Russell, Anthea Clarke, Mary C. Geneau, Luke Stutter, and Matthew Driller.

Supervision: Haresh Suppiah and Matthew Driller. All authors have read and agreed to the published version of the manuscript.

CONFLICT OF INTEREST STATEMENT

The authors declare that they have no conflicts of interest.

ACKNOWLEDGEMENTS

Open access publishing facilitated by La Trobe University, as part of the Wiley - La Trobe University agreement via the Council of Australian University Librarians.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

ETHICS STATEMENT

The present study was approved by the Human Research Ethics Committee at La Trobe University.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

How to cite this article: Boukhris, O., Suppiah, H., Halson, S., Russell, S., Clarke, A., Geneau, M. C., Stutter, L., & Driller, M. (2024). The acute effects of nonsleep deep rest on perceptual responses, physical, and cognitive performance in physically active participants. *Applied Psychology: Health and Well-Being*, *16*(4), 1967–1987. https://doi.org/10.1111/aphw.12571